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ABSTRACT

This report summarizes information about student achievement, student opportunity to learn in science and mathematics, and student variables relating to that achievement for elementary and secondary students in the state of Illinois. Five tests were used for the basis of this report: The Illinois Inventory of Educational Progress, the American College Test (ACT), the Scholastic Aptitude Test (SAT), the High School and Beyond Test (HSB), and the Decade Study. The major findings indicate that (1) Illinois students' performance in high school science is essentially the same as the average performance nationally, (2) elementary school mathematics achievement in Illinois has risen significantly since 1976, (3) average mathematics scores for Illinois high school students are approximately the same as the national average on national tests, (4) state ACT scores in mathematics are lower than in 1972, (5) state SAT scores in mathematics remained stable throughout the 1970's, (6) Illinois high school level mathematics achievement is significantly lower that in 1970 on the Decade Study Test, (7) there are no significant differences between student performance in public and private high schools in the state on the ACT and HSB, and (8) male students score significantly higher than female students in mathematics and science in Illinois (the differences have decreased in mathematics and increased in natural science). (PN)

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SCIENCE AND MATHEMATICS ACHIEVEMENT IN ILLINOIS

A Perspective Based on Test Results

Prepared by The

Program Evaluation and Assessment Section
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Illinois State Board of Education

U.S. DEPARTMENT OF EDUCATION
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Introduction

The Governor's Task Force on the Quality of Education in Mathematics and Science in Illinois faces the complex task of examining issues related to achievement in elementary and secondary education. Readily available information does not provide answers to all of the possible concerns, however the major questions which can be addressed through achievement data include: How well do Illinois student perform on tests of science and mathematics? How does that performance compare to performance elsewhere? Do some identifiable groups of students perform better than others? What conditions influence that performance?

This report summarizes information about student achievement, student opportunity to learn in science and mathematics, and student variables relating to that achievement. Five tests are used as the basis for this report: The Illinois Inventory of Educational Progress (IIEP), The American College Test (ACT), the Scholastic Aptitude Test (SAT), the High School and Beyond Test (HSB) and the Decade Study (DST).

The IIEP is a moderately difficult test administered annually by the State Board of Education to a representative sample of fourth, eighth, and eleventh grade Illinois students. The IIEP has tested students in science twice and mathematics seven times since 1976. Additional information is also gathered by the IIEP through student, teacher, and principal questionnaires.

The HSB is also a moderately difficult test which contained science and mathematics sections. The senior class of '80 (representative samples of Illinois and U.S. twelfth grade students) took the "senior" test in 1980. The senior class of '82 took the "sophomore" test in 1980, and the same students took that identical test again in 1982 when they were seniors.

The ACT and SAT are college entrance examinations which provide information about student knowledge in science and math. The number of Illinois students taking the ACT increased from 89,969 in 1972 to 112,948 or 2/3 of high school juniors in 1980. The number of Illinois students taking the SAT has decreased each year since 1973, from a high of 30,675 in 1973 to a low of 21,535 in 1983. ACT scores range from 1-36; SAT scores range from 200-800. Student questionnaires are given as part of both tests.

The DST is a difficult high school level test. It was administered to a representative sample of Illinois eleventh grade students in November, 1981.

Major Findings

- The average Illinois performance in high school science is essentially the same as the average performance nationally.

- Illinois achievement in elementary school mathematics has risen significantly since 1976.

- The average mathematics scores for Illinois high school students are approximately the same as the U.S. on national tests.

- Illinois ACT scores in mathematics are lower than in 1972.

- Illinois SAT scores in mathematics remained stable throughout the 1970's.

- Illinois high school level mathematics achievement is significantly lower than in 1970 on the Decade Study Test.

- There are no significant differences between student performance in public and private high schools in Illinois on the ACT and HSB tests.

- Male students score significantly higher than female students in mathematics and science. The differences have decreased in mathematics and increased in natural science.

- Analysis of student capability indicates that students of the lowest level of capability have declined in their mathematics achievement over time.

- Student performance in science was stable at all capability levels over time.

Elementary Level Science

Information available to the State Board of Education about what elementary school students know in science is limited to one source -- the Illinois Inventory of Educational Progress. Fourth and eighth graders were tested on the IIEP both in 1977 and 1981 on life science, physical science, scientific methodology and application. Life science items includes questions about plants and animals. Physical science items are natural laws, electricity, and other phenomena. Items about scientific methodology include experimental process and hypothesis testing. Application items require the student to use knowledge to solve problems.

The IIEP

In 1977 fourth graders performed significantly higher in life science than in physical science averaging 53% compared to 49% correct. In 1981 performance was highest in scientific methodology (51%) and lowest again in physical science (47%). This pattern suggests that at least for the items tested, physical science may receive less emphasis in fourth grade than life science or scientific methodology.

Eighth grade science results from 1977 show that life science performance (73%) was significantly higher than performance in physical science (69%). The results are reversed in 1982. Physical science performance (70%) is significantly higher than performance in life science (64%) and scientific methodology (67%). Table 1 shows these results.

Some educators have suggested that schools may emphasize lower cognitive skills in science such as recall to the detriment of advanced skills such as problem solving. The 1981 IIEP included items on the application of knowledge in physical science and scientific processes, an advanced skill which suggests a possible answer to that question. Fourth graders did as well on application as they did in other types of items. Eighth graders performed significantly better than average on application skills in physical science. These results suggest that elementary students acquire advanced skills as well as fundamental ones. See Table 2 for the results.

These results indicate that considerable difference exists between fourth and eighth grade performance. In 1977, the fourth to eighth grade gain was 26 points. On a similar test in 1981 the gain was 22 percentage points.

Secondary Level Science

Achievement data on high school science is based on the IIEP, the HSB, the ACT, and the SAT.

The IIEP

The IIEP results from 1977 show that average eleventh grade performance is highest in life science, next in scientific methodology, and lowest in physical science. In 1981, 11th grade students again scored high in the life science (73%) and scientific methodology (75%). The lowest performance was in physical science (67%). (See Table 1)

The SAT

The SAT information used in this report reflects performance on the Science Achievement tests (not the SAT quantitative test) which are designed to provide colleges with information on a student's performance in specific areas of science. Table 3 shows a comparison between Illinois and U.S. performance. Illinois averages are slightly higher than national averages (but not to a significant extent) in Biology, Chemistry, and Physics performance.

Additional information from student questionnaires indicates that more than 90% of the college bound Illinois students who take the SAT have taken at least one course in science, with more students taking courses in biological science than in the physical sciences. Student responses also indicate that more female than male students take additional courses in biology while more college-bound male than female students take physical science courses. Table 4 shows the SAT questionnaire information about the number of courses in science.

The ACT

The American College Test (ACT) Natural Sciences Reading Test contains 52 items dealing with reasoning and problem solving skills. The multiple choice test of 52 items is converted to a 36 point scale for reporting results. ACT science scores have remained stable since 1970. See Table 5. The highest average during this time was 21.3 in 1973 and the lowest average (20.6) occurred in 1976 and 1978. The range of averages covers only .7 of a point in Illinois. Compared to national averages Illinois students ranged from .4 above the average in 1972 to .3 below the average in 1978. Since that time, the state average and the national average has been virtually the same.

HSB

The High School and Beyond science test for sophomores of 1980 and seniors in 1982 contained 20 items. The content included items about biology, physical science, science process, and application of scientific knowledge. The sophomores of 1980 averaged 11.1 items correct (56%). The same students as seniors in 1982 averaged 11.6 (58%).

Elementary Level Mathematics

The IIEP

Elementary school mathematics is defined as the general mathematics studied in grades 1-8, plus the first semesters of algebra and geometry. Achievement of Illinois fourth and eighth grade students is high in computation with whole numbers and mathematical concepts, moderate in application, and low in measurement and geometry. Additionally, achievement of eighth grade students is high in fractions and moderate in algebra. Table 6 shows the aggregate data from seven years of IIEP tests in mathematics.

Since the IIEP began in 1976, student achievement has been higher in subsequent tests at both fourth and eighth grade levels almost every year since that initial year. In 1983, fourth and eighth grade scores approached but did not equal the highest scores attained in 1979 and 1980 respectively. Figure 1 shows the IIEP trends in mathematics for the years 1976-1983.

Secondary Level Mathematics

Illinois students have consistently averaged about the same as students nationally in mathematics. Comparisons between Illinois and the nation are available on three tests, the HSB, the ACT, and the SAT.

High school students were tested in general mathematics (arithmetic, statistics, and first semester algebra and geometry) on the IIEP and the HSB, and more advanced mathematics items were included in the ACT, SAT, and DST.

The IIEP

Eleventh grade IIEP scores were at their highest level ever in 1983. Figure 2 shows the trends from 1976 to 1983 for eleventh grade on the IIEP tests in mathematics. Achievement of eleventh grade students is high in computation of whole numbers and mathematical concepts; moderate in fractions, application, algebra, and statistics; and low in measurement and geometry. Table 7 shows the aggregate data for seven years of IIEP tests in mathematics.

The HSB

Representative Illinois and national samples of sophomores and seniors took the High School and Beyond general mathematics tests in 1980. Both groups scored essentially at the mean for the U.S. Table 8 shows the results.

The high school graduating "class of '82" took a 38-item "sophomore" mathematics test in 1980, and the same students took that identical test again in 1982. Scores rose from a mean of 18.7 items correct in 1980 to 21.0 in 1982.

The ACT

Illinois students have scored essentially the same as students across the U.S. on the ACT for the past 10 years. Table 9 shows the comparisons for Illinois and the U.S. from 1972-1982. Illinois mean scores were never below the national average during this time. Scores for Illinois and the nation on the ACT have been stable since 1976. However, there was a decline in scores of Illinois students parallel to a national decline from 1972 to 1975.

The SAT

SAT scores for Illinois students have remained stable for the past 10 years, ranging from a low of 507 in 1971 and 1976 to a high of 517 in 1982. The scores were 509 in 1970 and 517 in 1982. Table 10 shows the scores for Illinois and the U.S. from 1970-1982. SAT mathematics scores for Illinois have remained stable since 1970, while national scores have dropped. At no time during this period have Illinois scores fallen below the national average. A small proportion of Illinois seniors take the SAT each year. A much larger proportion of students in other states take it each year. The Illinois sample may be a select group, and comparisons should be made with caution. The best comparisons are for high ability students taking the test. The top Illinois students compared favorably with the top students in the rest of the country. (see Table 11).

The DST

The DST contained a 60-item mathematics test which is a test of advanced high school mathematics. Advanced high school mathematics is defined as second semester algebra and geometry, higher levels of algebra and geometry, trigonometry, and calculus. The DST was administered to representative samples of eleventh grade Illinois students in 1970 and 1981. Scores for the two groups were 20.8 in 1970 and 19.1 in 1981. The 1970 students performed significantly better than the 1981 students.

Variables Related to Performance

Achievement in mathematics and science can be viewed from the perspective of background variables. These add a contextual understanding to the results. Four variables are available for this report. These are type of schools - private or public; ethnicity of students, gender of students, and student capability.

Public and Private School Achievement

Two sets of mathematics and science achievement data are used to compare students from private and public schools. These two sets of data are from the American College Test (ACT) and the High School and Beyond Study (HS&B).

Table 12 presents ACT achievement data for Illinois students in private and public schools. There are only slight differences between the mathematics and natural science performance of Illinois students from private and public schools. The differences are neither statistically nor educationally significant.

The High School and Beyond results for private and public school students are also presented in Table 12. These data were drawn from students who were seniors in high school in 1982. The results from the mathematics subtest mirror those of the ACT. That is, significant similarities in performance are found for Illinois students in private and public schools in mathematics achievement. On the science subtest, a difference of 0.8 points for students taking the test is noted, but it is a nonsignificant difference

Ethnicity and Differences in Achievement

The comparison of test results from ethnic groups should include consideration of such variables as income and parental level of education in order to be useful for policy purposes. These complex analyses are under way and the full results for interpretation of ethnic differences will be available at a later time. At this point we are reporting the portion of the analysis which contains achievement score differences. Differences in mathematics and science performance of Illinois students from various ethnic groups are derived from two separate instruments: the ACT and the IIEP. Table 13 presents the differences from the ACT subtests of mathematics and science.

ACT results show the same patterns for achievement in mathematics and science, - highest achievement for Asian and White students, lower scores for Hispanic, Mexican and American Indian students, and lowest scores for Black students, who score only one-half that of White and Asian students. The gaps are wider in mathematics than in science.

Recent analysis of data from the National Assessment of Educational Progress (1982) has suggested that Blacks have gained in achievement (1970-1980) and narrowed the gap. The IIEP was also analyzed for changes in the gap. Table 14 presents the differences for Black and White student performance on the IIEP mathematics tests for 1979, 1980, and 1981. For mathematics achievement, the gap between Black and White students has narrowed at the eighth and eleventh grades, while a plateau has occurred at the fourth grade. In terms of science achievement, Black and White differences from 1977 to 1981 show an opposite trend. Scores of Black and White students at fourth and eleventh grades are almost twice as far apart in 1981 as they were in 1977. Thus, while the Black and White gap is closing in basic mathematics, it is becoming wider in science.

Gender Differences in Achievement

Differences in performance between male and female students have been the center of study for a long time. The ACT and HSB results are used here as one basis for male and female comparisons in mathematics and science.

The results on the ACT from 1972 through 1982 are provided in Table 15. This is an average difference of 2.78 standard points between male and female students on the ACT mathematics test. The largest differences were 3.1 standard points between male and female students in 1975 through 1977. Since that time, the difference between the male and female students, while significantly apart, has begun to narrow.

The differences between scores of male and female students on natural science vary from year to year. The smallest difference between male and female scores was 1.7 points in 1972. The largest difference was 2.7 points in 1975-76. Since 1978, the ACT difference between male and female students in science is becoming wider.

The gender differences on the High School and Beyond are given on Table 16. There is a one point performance difference between the achievement of male and female students in mathematics and science, but due to the sampling design of the High School and Beyond, this difference was not statistically significant.

Student Capability and Achievement

Recent national analyses of achievement data have focused upon the performance differences of students with varying levels of capability. One possibility is that declines in achievement may be associated with students who can be defined by their specific performance levels on the test.

The most representative set of Illinois high school results comes from the ACT. Due to the large sample size, it is possible to distinguish among the performance of the students in terms of differing levels of capability. This differentiation pinpoints those students who may well be having continuing problems in a particular area. Table 17 presents the ACT results for Illinois students in mathematics and natural science in terms of student capability in 1970, 1975, 1981, 1982. (These years were chosen as benchmarks to summarize data across the past 13 year time span.) The results indicate that there has been no evidence of change in natural science achievement of college bound high school students in any quartile of capability from 1970 to 1982. However, in mathematics, a dramatic difference of 4.8 standard score points is noted for the lowest quartile of student capability between 1970 to 1982. That 4.8 score point difference represents a 32% drop in achievement between 1970 and 1982, for these low capability students.

Table 1
IIEP Performance in Topic Areas (Stated as Percentage)

	Grade 4		Grade 8		Grade 11	
	1977	1981	1977	1981	1977	1981
Life Science	53	50	73	64	89	73
Physical Science	49	47	69	70	65	67
Scientific Methodology	51	51	72	67	77	75

Table 2

IIEP

Performance in Advanced Science Skills
in Application of Knowledge
(Stated as Percentage)

Grade	Total Science Average	Physical Science	Scientific Processes
4	47	45.9	45.9
8	69	73.9	70.9
11	77	80.9	79.3

Table 3
SAT Achievement Tests
Illinois and the Nation

Subject	Illinois	Nation
Biology	573	544
Chemistry	608	569
Physics	630	595

Table 4
Student Exposure to Science

	Biological Sciences		Physical Sciences	
Total Number of Students Responding	M 10,860	F 10,941	M 10,859	F 10,926
Total Proportion of Students Having Had Courses In Sciences	93.5	96.1	94.1	90.7
Proportion With 1	69.0	68.6	25.6	40.2
2	20.8	23.6	39.0	35.3
3.	2.7	2.8	23.6	13.2
4	.7	.7	4.7	1.5
5+	.3	.4	1.2	.5
Courses				
Total Proportion of Students Without Courses in Sciences	6.5	4.0	6.0	9.3

Table 5
Mean ACT Science Scores for
Illinois and the U.S.

	Illinois	U.S.
1972	21.2	20.8
1973	21.3	20.8
1974	21.1	20.8
1975	21.2	21.1
1976	20.6	20.8
1977	20.7	20.9
1978	20.6	20.9
1979	20.9	21.1
1980	20.9	21.1
1981	20.9	21.0
1982	20.7	20.8

Table 6
Summary Performance of Fourth and Eighth Grade Illinois Students
on the Illinois Inventory of Educational Progress
Over Seven Years of Tests*

	Percentages Correct	
	Grade 4	Grade 8
Whole Numbers	75%	67%
Mathematical Concepts	64%	60%
Fractions	**	68%
Algebra	**	57%
Application	60%	54%
Measurement	44%	44%
Geometry	35%	48%

* Individual items were averaged, then a grand mean computed
** indicates insufficient data

Table 7
Summary Performance of Eleventh Grade Illinois Students
on the Illinois Inventory of Educational Progress
Over Seven Years of Tests*

	Percentages Correct
	Grade 11
Whole Numbers	86%
Mathematical Concepts	67%
Fractions	63%
Algebra	61%
Statistics	60%
Application	59%
Measurement	53%
Geometry	47%

* Individual items were averaged, then a grand mean computed

Table 8
High School and Beyond
Mean Test Scores for Students
in Public Schools - Spring 1980[a]

Geographical Region	Sophomore Test (38)[b]	Senior Test (32)
Illinois	18.7 (49.2)[c]	19.2 (60.0)
Other North Central	19.7 (51.8)	19.9 (62.2)
New York	19.6 (51.6)	20.7 (64.7)*[d]
Other North East	19.3 (50.8)	19.9 (62.2)
South	16.6 (43.7)*	17.4 (54.4)*
West	19.3 (50.8)	19.5 (60.9)
Total United States	18.5 (48.7)	19.1 (59.7)

[a] All means are weighted to better reflect the population values because of the two-stage stratified sampling design used.

[b] Numbers in parentheses indicate number of items per test.

[c] Numbers in parentheses indicate percentages of items correct.

[d] Asterisks indicate scores significantly different from Illinois scores at the .01 level.

Table 9
Mean ACT Mathematics Scores for Illinois and the U.S.
1972-1982

	Illinois	U.S.
1972	20.2	19.1
1973	19.1	18.3
1974	18.1	17.6
1975	17.7	17.5
1976	17.7	17.4
1977	17.5	17.5
1978	17.5	17.5
1979	17.6	17.4
1980	17.6	17.3
1981	17.6	17.2
1982	17.3	16.9

Table 10
Mean SAT Quantitative Scores for Illinois and U.S.
1970-1982

Year	Illinois	U.S.
1970	509	488
1971	507	484
1972	509	481
1973	513	480
1974	510	472
1975	509	472
1976	507	470
1977	511	468
1978	511	467
1979	507	466
1980	508	466
1981	515	467
1982	517	468

Table 11
SAT Achievement Test Scores

Mathematics Level 1			Mathematics Level 2	
Illinois	U.S.	Score	Illinois	U.S.
%	%		%	%
3	2	750-800	26	16
7	4	700-749	23	19
14	9	650-699	21	21
18	15	600-649	17	21

Table 12
ACT Normative Data for Illinois
1975 - 1976

	English	Mathematics	Social Studies	Natural Science
Private:	17.9	17.9	17.4	20.6
Public:	17.3	17.8	16.9	20.7
Difference:	0.6	0.1	0.5	0.1
		1982-83		
Private:	18.5	17.1	17.6	20.5
Public:	17.8	17.4	17.1	20.8
Difference:	0.7	0.3	0.5	0.3

High School and Beyond Sample Data for Illinois
1982-83

	Mathematics	Science
Private	21.2	11.4
Public	21.0	12.2
Difference	.2	.8

Table 13
Ethnic Differences in Performance of Illinois Students
The American College Test (1982 - 1983)

	Mathematics	Science
Asian	20.3	20.7
White	18.7	21.9
American Indian	13.4	17.9
Other	12.8	17.4
Hispanic	12.3	16.6
Black	9.9	14.8

Table 14
Differences in Performance Between
Black and White Students on the IIEP

Mathematics

Year	Fourth Grade	Eighth Grade	Eleventh Grade
1979	4.18	10.27	10.09
1980	4.55	8.16	8.81
1981	4.48	6.79	7.90

Science

Year	Fourth Grade	Eighth Grade	Eleventh Grade
1977	2.96	6.10	4.77
1981	4.53	7.01	9.47

Table 15
Differences in Performance of Illinois
Male and Female Students on the ACT

	Mathematics	Natural Science
1972 - 1973	2.4	1.7
1973 - 1974	2.7	2.5
1974 - 1975	3.0	2.3
1975 - 1976	3.1	2.7
1976 - 1977	3.1	2.2
1977 - 1978	2.9	2.5
1978 - 1979	2.9	1.9
1979 - 1980	2.7	2.2
1980 - 1981	2.8	2.3
1981 - 1982	2.6	2.5
1982 - 1983	2.6	2.5
AVERAGE DIFFERENCES	2.8	2.3

Table 16
The 1982 High School and Beyond Test

Male Students	21.5	12.7
Female Students	20.5	11.7

Table 17
Illinois Trends in ACT by Ability Quartiles

Mathematics

Quartile	1970	1975-76	1981-82	1982-83
Lowest	14.8	12	11	10
Second	20.0	17.5	18	18
Third	26.8	24.5	24	24
Highest	34	33	34	32

Natural Science

Quartile	1970	1975-76	1981-82	1982-83
Lowest	16.4	15.5	16	16
Second	20.6	20.4	21	21
Third	26.5	25.8	26	26
Highest	33	33	33	33

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Figure I

Trends in Mathematics 1976 - 1983

The Illinois Inventory of Educational Progress

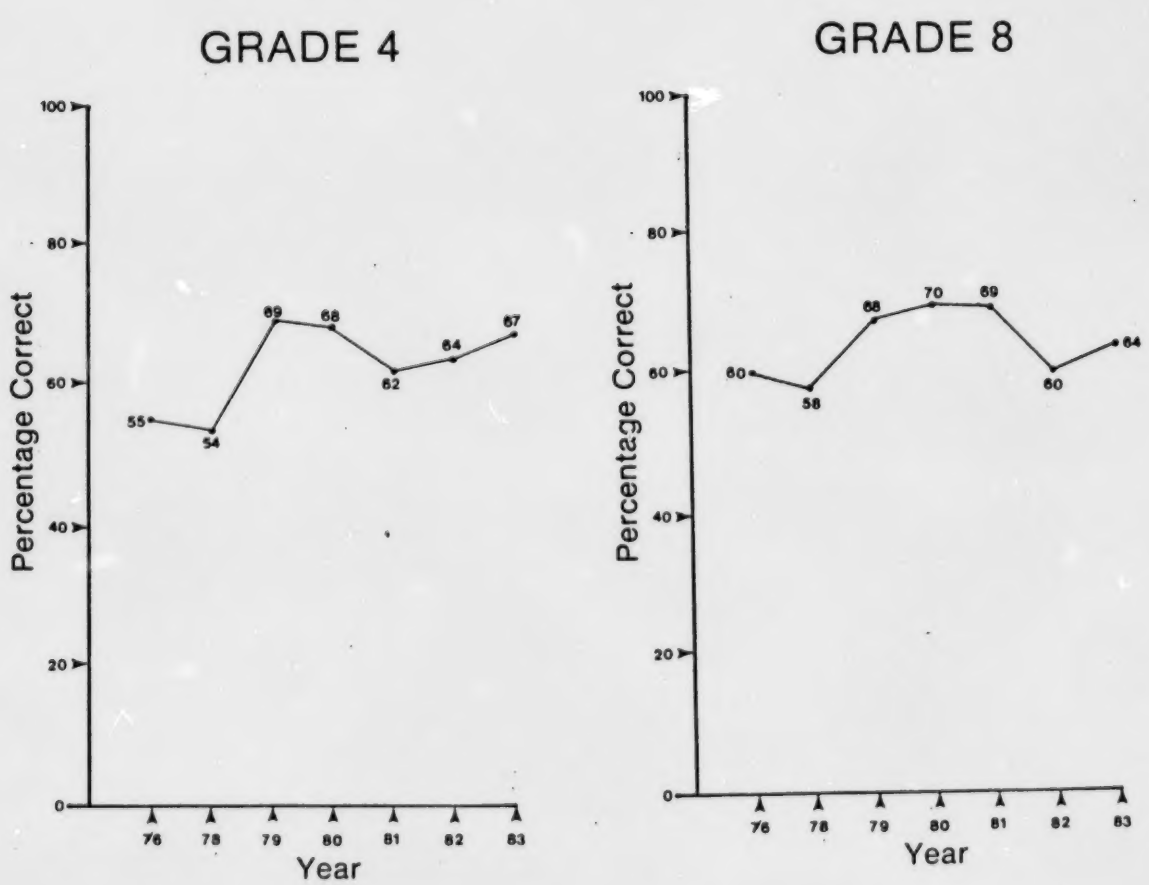

Figure 2

Trends in Mathematics 1976 - 1983

The Illinois Inventory of Educational Progress